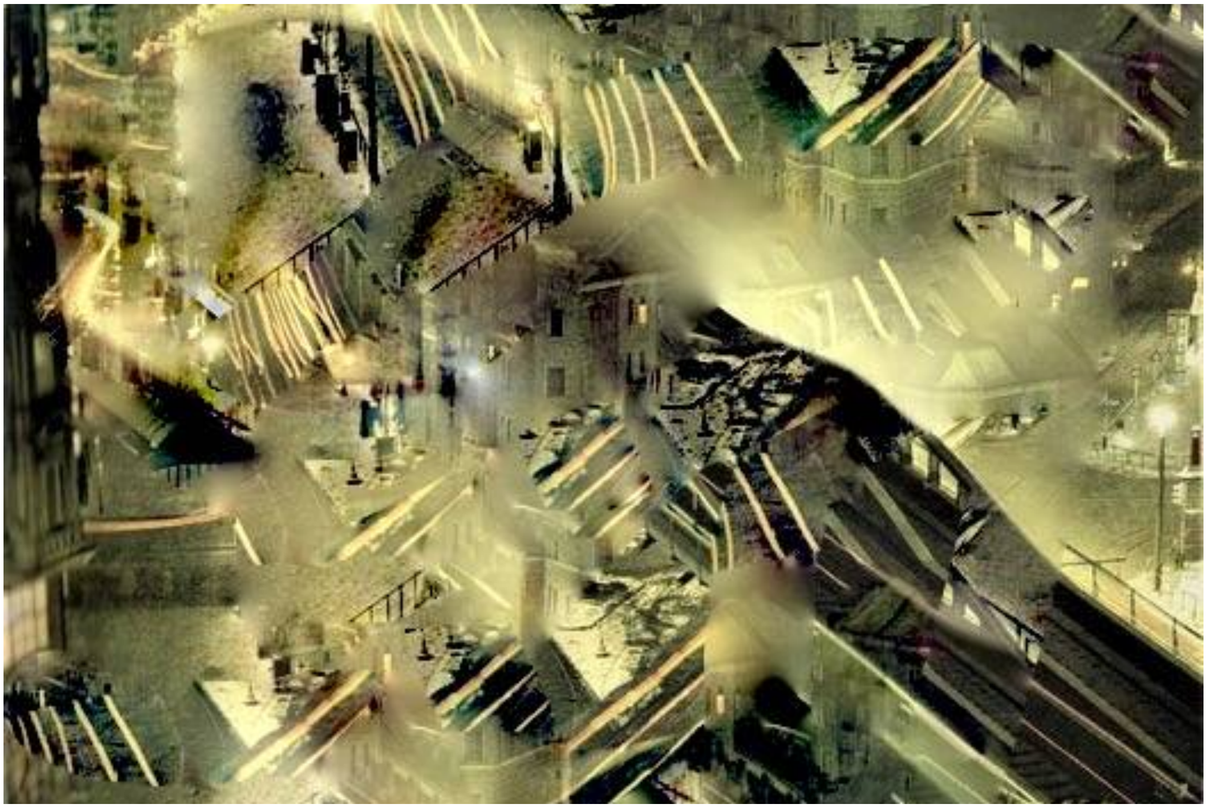
☰



ZAFER ARACAGÖK 2022-10-29

QUANTUM THEORY AND THE QUESTION OF FOUNDATION

GENERICSCIENCE BOHR, COMPLEMENTARITY, EINSTEIN, MATERIALISM, NONLOCALITY, QUANTUM PHYSISCS

The following fragment comes from my book, *Desonance: Desonating (with) Deleuze* in which I outline Arkady Plotnitsky's views on the distinctions between Einstein and Bohr on the basis of the question of foundation or ground with respect to Quantum Theory.

All my attempts, however, to adapt the theoretical foundation of physics to this [new type of]

knowledge failed completely. It was as if the ground had been pulled out from under one, with no firm foundation to be seen anywhere, upon which one could have built. That this insecure and contradictory foundation was sufficient to enable a man of Bohr's unique instinct and tact to discover the major laws of the spectral lines and of the electron shells of the atom together with their significance for chemistry appeared to me like a miracle – and appears to me as a miracle even today. This is the highest musicality [höchste Musicalitat] in the sphere of thought. A. Einstein[1]

I get to think of my own thoughts of the situation in which I find myself. I even think that I think of it, and divide myself into an infinite retrogressive sequence of "I"s who consider each other. I do not know at which "I" to stop as the actual, and the moment I stop at one, there is indeed an "I" again which stops at it. I become confused and feel dizziness as if I were looking down into a bottomless abyss… (quoted by N. Bohr) [2]

First of all, I would like to stress that this quotation from Einstein comes from "Autobiographical Notes," and the way it is related to what Einstein calls the "musicality" of Bohr's work is underlined by the debate between him and Bohr. As we know it from different sources, but especially from Plotnitsky, the main dispute between Einstein and Bohr, was the question of foundation, the foundations of classical physics[3] which were highly shaken by the discoveries of Max Planck.[4]

Therefore when Einstein writes with admiration and also amazement about Bohr's work, which is developed on such an "insecure and contradictory foundation," he also explains the core of the dispute almost in a nutshell: "It was as if the ground had been pulled out from under one, with no firm foundation to be seen anywhere, upon which one could have built." For him, as is widely known, in a universe where "the god does not play dice with the universe," to work without foundation was inconceivable. As for the use of "musicality" of Bohr's work, one can refer to Einstein's infatuation for music: "If I were not a physicist, I would probably be a musician. I often think in music. I live my daydreams in music. I see my life in terms of music. (…) I get most joy in life out of music."[5] In contrast, Bohr was a very bad piano player.[6] Given this information, such a reference, although it can explain the high veneration which Einstein had for music, is still far away from throwing light on the proximity between Bohr's position as having no foundations and the "musicality" of his work for Einstein. Did Einstein think about a musicality without foundations when he wrote: "This is the highest musicality in the sphere of thought"? Such a question, without doubt, demands a detailed account of the debate between Einstein and Bohr, yet since to reconstruct it in its fullness twould be an ambitious project I would like to concentrate on several aspects of it, such as, causality, time-space, visibility, continuity/discontinuity, and complementarity.

As Plotnitsky observes:

Quantum physics was inaugurated in 1900 by Max Planck's discovery, widely seen as the single greatest discovery in twentieth-century physics, that radiation, such as light (very high frequency electromagnetic waves), previously believed to be a continuous (wavelike) phenomenon in all

circumstances, can, under certain conditions, have a quantum or discontinuous character. [7]

During the course of later developments, another radical step was taken by Einstein who put forward a particlelike understanding of light in order to explain Planck's discovery of discontinuity. If according to the classical view, the light behaved as waves, the Einsteinian discovery saw them as particles of light which were called "electrons," or "photons." "The light acquired a more explicitly dual, wave and particle, character each manifest in different experimental circumstances which classical physics did not appear able to explain."[8] Strangely enough, one of the main difficulties for the classical view was the impossibility of observing the wavelike and particlelike character of light at the same time which did not allow any visualisation, or representation of the quantum phenomena in a proper picture. As Bohr, would explain it by his concept of complementarity, the wavelike and particle character of light were two mutually exclusive characters of quantum phenomenon which cannot be observed simultaneously at the same time, and therefore it required a different approach – an approach which was unknown until that time to classical physics. The concept of *complementarity*, as it was coined by Bohr, would be used to explain this mutual exclusiveness, (in a similar fashion to Derridaean manoeuvre of maintaining the opposites at the same time) and would come to "designate Bohr's overall interpretation of quantum mechanics and, then, a general philosophical conceptuality."[9]

If the main question was how one and the same object could have such opposite characteristics, such as wavelike one time, and particlelike at another, further experiments bore witness to another realization that "wavelike" and "particlelike," not even as attributes could be ascribed to quantum objects, because these, together with other attributes like momentum, and motion are still those classical concepts which were used in order to explain the radically new phenomena. In other words, what was really at stake was the *visibility* of quantum objects[10] – which the classical physics took for granted – and therefore, it brought along also some other questions as to whether quantum objects could be called "objects."[11] It all meant that now the classical physics was face to face with the "unknowable" which is observable or visible only in its effects. However, as Plotnitsky corrects, the unknowable objects of quantum phenomena are "efficacies" which are accessible to us only in their effects that can be observed within the concepts of classical physics. As he puts it, "I use the term "efficacity" in its dictionary sense of power or agency producing effects but, in this case, without the possibility of ascribing this agency causality, which point is especially significant in quantum theory and in Bohr's work."[12]

This, of course, together with the concept of complementarity, pointed to another radical break from the classical way of understanding nature, that is, from understanding it through cause and effect relationship. If one could raise questions about even the objectness of the quantum objects – which are thinkable only as efficacies and observable only in their effects – it also necessarily put into doubt the concept of causality. The classical physics, working on the principle of causality, required first and foremost, the construction of a model according to which the interaction between the natural objects and the natural phenomena can be observed, measured, theorised, explained, and verified. However, in quantum mechanics, since, only the interaction between the effects of the efficacies and the measuring instruments could be

described, it did not allow for a construction of such a model. It is, therefore, right at that point, Bohr's concept, complementarity, gained another significance for it acknowledged the disappearance of models by referring to the impossibility of maintaining a total picture of the quantum phenomena due to the mutually exclusive character – wave and particle – of quantum objects. Yes, the wave-effect or the particle-effect of the unknowable "objects" were completely visible and definable according to the set-up of the experiment[13], but since each set up would give only a partial definition of the effect – not the efficacy itself – the whole phenomena would never be visualised with respect to a model, and, therefore, should be thought in a complementary relationship.[14]

All this required a renunciation or a revision of not only the causality and visualisation but also, as Bohr put it, "our attitude towards the problem of physical reality."[15] If the unknowable which was "knowable" only through its effects, that is, still through the concepts of classical physics, then such a situation also required a revision of what constituted this "reality" which hardly obeyed the model of a model, or, rather the concept of a model according to classical physics. As Plotnitsky offers, the classical physics, or Newtonian mechanics can be interpreted as *realist* "because it can be seen as fully describing all the (independent) physical properties of its objects necessary to explain their behaviour. At least, again, such is the case for idealised systems or at the level of classical models, when, more immediately, the properties in question are abstracted from other properties of the objects comprising a given system. The resulting model can then also serve as a model for more complex and less tractable systems."[16] However, in contrast to such classical, causal and deterministic ways of constructing models, the quantum phenomena proved that such a concept of model did not properly work because in quantum that which was taken for granted – physical reality *as such* – was at stake. Consequently, if such a presumption could not be made, then, without doubt, the construction of a model, even the construction of a model of a model would fail – a lack of foundations which terrorized Einstein in Bohr's theory. As Plotnitsky explains:

It is this irreducible and irreducibly unbridgeable rupture, a properly quantum discontinuity (perhaps the only true discontinuity in quantum physics), that defines the difference between nonclassical thinking, found in quantum physics and any realism.[17]

This approach to "physical reality" not only what determines the basic distinction between Einstein and Bohr on epistemological level but also and mainly is what best foregrounds Bohr's concept of complementarity, and his approach to models, copies, or rather, the question of mimesis that it encapsulates. From this angle, I believe, the quantum theory can be seen as a crisis in representation, models and mimesis which raised doubts about classical methods, the "Platonic" model of a model, by way of which science in general had been capable of representing the phenomena as "reasonable." With the rise of the quantum phenomena, however, what is put at stake – given the impossibility of constructing a model on a certain "physical reality," and therefore the impossibility of having a total picture – is the visibility of the phenomena, and hence its representability. In order to outline the basic characteristics of this crisis, I would like to offer that we should follow the ways in which Arkady Plotnitsky develops

distinctions between Bohr's and Einstein's approaches to quantum phenomena.[18]

1. *Idealization Deidealization*

For the classical physics time and space were the two fundamental necessities if things would be observable. However, quantum mechanics, pushing the visibility of things into crisis, brought along the suspension of time-space determination. In other words, if there was not a total picture available in the quantum field, this also problematized the time-space coordination. With this move, Bohr deidealized the classical concepts which were used to approach quantum physics. In contrast, Einstein, by introducing the time as the fourth dimension, reinvented the *synthesis* by rendering time-space question into a unity, that is, back into continuity, but did not think of it in a complementarity, in a continuity-discontinuity complementarity. If Bohr, in this sense, was pursuing a radical deidealization of the idealized, Einstein idealized the unidealizable. [19]

2. *Continuity Discontinuity*

Discontinuity of the quantum phenomena, the most fundamental claim of Planck's discovery in 1900, led Bohr to a comprehensive understanding of how deeply classical physics was dependent on it, basically, in its relationship to causality, which determined all perception, interpretation, conceptualisation, and theory. For Bohr, "[Every] notion, or rather every word, we use is based on the idea of continuity, and becomes ambiguous as this idea fails."[20] However, as Plotnitsky points out, Bohr's was not an absolutisation of the opposition, but the radicalisation of the difference, between continuity and discontinuity in a complementary relationship.

3. *Randomness and Causality*

Einstein's move to bring back continuity into quantum physics was solely determined by his insistence on "foundations," that is, by the irreducibility of chance in quantum which did not allow for a solid ground – foundations that could only be firmly constructed on a concept of causality. Without continuity – introduced by Planck's discovery – there remained no causality and vice versa.

4. *Completeness and Incompleteness*

Einstein-Podolsky-Rosen argument (1935), known as EPR argument, was designed to criticize Bohr's quantum theory on the basis of its "incompleteness." As Plotnitsky summarizes it:

The EPR argument concerns a situation in which both the position and momentum of a particle could be predicted definitely – without uncertainty – in view of the following consideration. Although, due to uncertainty relations, in quantum mechanics one can never simultaneously measure both the momentum and position of any particle with full precision, quantum mechanical formalism does allow one to calculate without uncertainty the combined momentum of and the relative distance between two particles. If these particles are, then, allowed to interact, the possibility of measuring *either* the position *or* the momentum of one of them at any given point (which is always allowed by quantum mechanics) and the law of momentum conversation (which applies under all conditions) allow one to calculate and predict with certainty the position

and momentum of the other particle. Since, EPR claims, in quantum mechanics such predictions of the exact value of conjugate variables (variables subject to uncertainty relations) are impossible, their argument would show the incompleteness of quantum mechanics by a certain – equally reasonable – criterion of physical reality.[21]

Bohr's reply to that is miraculated, if we are allowed to use a term by Deleuze and Guattari, along the lines of continuous-discontinuous complementarity, where the complete is understood as something which is complete not because complete-incomplete is understood as yielding to a synthesis but is seen in a complementary relationship. In this sense, Bohr did not deny the incomplete completeness of the quantum, but at the same time he deconstructed Einstein's and therefore classical physic's understanding of completeness based on continuity and causality.[22]

5. *Correspondences*

Bohr's correspondence principle asks for a reinterpretation of all the classical concepts upon which depends our interpretation of all experience, and, hence, it offers a certain sense of correspondence between the classical and the non-classical. However, "a certain sense" here denotes a correspondence that does not quite correspond for such a task should always be informed by a complementarity of continuity and discontinuity between two realms. Arkady Plotnitsky has the unique approach to the correspondence between Einstein and Bohr via Derrida's critique in *The Postcard, From Socrates to Freud and Beyond*. He offers that the correspondence principle has an analogy in Derrida's reading of "correspondence" in a general economy where sent messages circulate always with a risk of not arriving the destination, and even if they arrive, they always arrive and not arrive at the same time. As Plotnitsky observes:

Einstein's letters to Bohr finally transmit or *continue* the letter, and spirit of Newton, or Kant or Hegel: the letter and spirit of continuum. Bohr's great letter to Einstein, the letter and spirit of complementarity, may never have arrived, although Einstein no doubt read all of Bohr's mail very carefully. There must have been a quantum gap or a quantum leap in the system and history.[23]

6. *Asyntheses*

Without doubt, one of the basic distinctions between Bohr and Einstein lies in each scientist's approach to the question of "synthesis." According to Plotnitsky, the differences on this point can be layered by accounting for Einstein's philosophical position which required the following assumptions: 1) the principle of *causality* and the absence of randomness; 2) the *continuity* of all mathematical representations, including time-space continuum; 3) the *completeness* of theory which meant a one-to-one correspondence between theory and "physical reality"; 4) the concept of *physical reality* which exists as independent of observation or interpretation. These, on the other hand, constituted Bohr's main points of argumentation against Einstein, on the basis of his thought on complementarity.

Bohr, as it were, continually asks in reply to Einstein: What does it mean that something is independent or has a given value, or even is defined as a variable or observable, such as position

or momentum? It means that certain experimental conditions can be arranged so that a given variable or a set of variables can be defined and if such variables were measured, which can only be done within such arrangements, they would have this or that value. Once such is he case, however, one cannot suspend the measuring process. For what does it mean to assume that a particle, or a wave, possesses a state or a real state, definite or given coordinate or momentum?[24]

As can be concluded from the way Bohr responded to Einstein's relativity theory, his critique took the form of a critique of – as we know it from Derrida – a "metaphysics of presence." In other words, the quantum physics, producing a critique of all the classical concepts and the classical physics on the basis of this metaphysics, also yielded to a radical sense of asynthesis, which should again be understood in a complementarity. If foundations could not be guaranteed by such a priori – metaphysical – assumptions then also the production of a moment of synthesis, along the lines of a certain Hegelianism,[25] would be at stake. In contrast, Einstein's reliance on a certain notion of physical reality – unavoidably metaphysical – assumed a grounding function in face of all the indeterminacy of the quantum physics.

The question of theoretical synthesis is at the heart of the argument between Bohr and Einstein, since one of the key reasons why Einstein rejected complementarity was that it made a conceptual synthesis impossible. In addition, for Einstein, such a synthesis had to be grounded in a specific conception of physical reality. According to Bohr, however, both become impossible under the quantum conditions, which demand both a very different epistemology or ontology, finally an anti-epistemology and an anti-ontology, and a very different notion of completeness of description.[26]

Insistence on synthesis in Einstein's case was realized by establishing a continuity with classical physics, and also within the theory of relativity itself. It is in this sense that Einstein's Hegelianism should be seen as an overcoming of the rupture discovered by Planck. However, for Bohr, as we have seen at the beginning of this section, what took the place of the synthesis was a concern for this rupture, the abyss.

*

Seen under the light of this debate between Einstein and Bohr, our scrutinisation of the question of foundations disturbs uncannily any concern related to "musicality," or "the highest musicality" of Bohr's work for Einstein. Given the radical discontinuity which determines Bohr's approach to quantum theory, why and how does Einstein still insist on hearing only a musicality? Is it because – for him – Bohr's theory can still be reappropriated *as such*, as a synthesis, despite its ground-breaking rejection of foundations? Can it be because EPR rejects *actio in distans* which, as a threat against the theory of relativity, would produce disruptions, discontinuities, and indeterminacies?

*

Bearing in mind these questions, it will be useful to add a seventh distinction to the Einstein-Bohr

debate, if only with the intention of offering an approach to this question of musicality by pointing to the question of "*actio in distans*" that played a significant role not only in classical physics since Newton but also in the EPR argument and Bohr's reply to it.

In classical physics a force is a push or a pull upon an object resulting from the object's interaction with another object. Whenever there is an interaction between two objects, there is a force upon each of the objects. When the interaction ceases, the two objects no longer experience the force. Force only exists as a result of an interaction. All forces between objects can be placed into two broad categories. 1) *Contact forces* are types of forces in which the two interacting objects are physically contacting each other, such as, in frictional, tensional, spring forces; 2) *action at a distance forces* where the two interacting objects are not in contact with each other, yet are able to exert a push or pull despite a physical separation, such as, gravitational force between the sun and planets despite the large distance between them, or electrical and magnetic forces. Action at a distance posed a difficult question before the Newtonian physics because it challenged the cause and effect framework on which it was built. In other words, Newton could explain in a mathematical formalism the momentum and the position of the objects in a cause and effect relationship with respect to the force of gravity which determined the contact forces between objects but not the force of gravity itself; and it posed even a greater difficulty when it came to the question of action at a distance because it foregrounded the metaphysical aspect of the classical physics.

Now if we return to the EPR argument, as it will be remembered, it focused on the question of whether quantum mechanics was incomplete for the physical reality it supposed could not be theorised *as such*. What Bohr argued in his reply was exactly this question of "physical reality" which was taken for granted by the EPR – a physical reality which worked very well insofar as the classical description of nature or reality was concerned. In other words, the quantum postulate had made it clear for Bohr that the discontinuity or the individuality of the atomic processes foregrounded not only the question of metaphysics in classical physics but it also problematized its applicability to quantum phenomena. Bohr's reply to EPR thus also led to the conclusion that the quantum mechanics was incomplete as far as the classical concept of completeness was concerned for it was obtained with reference to what was defined as "physical reality."[27] However, it was complete insofar as the complementarity of the situation was concerned, that is, when the completeness and incompleteness were considered in a complementary relationship. Bohr, in this way, introduced an uncompromising logic into quantum mechanics as a result of which the subsequent responses by Einstein focused on the possible action at a distance, or nonlocality[28] of quantum mechanics rather than on its incompleteness. At the cost of simplifying a whole scale complex argument, it can be said that the cause and effect principle, which saved Newtonian physics, even in the face of *actio in distans*, by means of a metaphysical postulate of force of gravity, led to the upsurgence of the same question this time in quantum mechanics. If efficacies could not be explained or verified, then quantum mechanics involved the question of action at a distance.

Einstein's argument on the question of the nonlocality[29] of quantum mechanics concentrated

on formulating an either/or situation according to which quantum mechanics was either complete but nonlocal or incomplete but local. In other words, quantum mechanics was either complete and allowing *actio in distans* or incomplete and not allowing *actio in distans*. However, the question of nonlocality, understood in classical terms, could apply only to the phenomena where the local could not be known due to some complications in measurement – yet, it did not mean that it could remain unknown if "proper" steps in measurement were taken. In contrast, the way Bohr argued against the claim of nonlocal but complete, or, local but incomplete argument of the EPR was by way of pointing to the radical discontinuity of the quantum world which made the effects knowable but not the efficacies themselves. As Plotnitsky claims:

Bohr agrees that quantum mechanics allows for and enables such ("at-a-distance") predictions and by so doing rigorously accounts for quantum correlations and entanglement. At the same time, however, it does not, in Bohr's interpretation, imply nonlocality, as some suggest. The entanglement/correlation part of the EPR-type argument can be adjusted so as to refer to the outcomes of measurements rather than to quantum objects, without, however reinstating nonlocality. In other words, entangled quantum objects (using this term with due nonclassical qualifications) or (Bohr shuns this language) "states" exist, but this only means (a) that particular forms of experimental detection (phenomena or effects) are possible and (b) that the quantum-mechanical formalism allows us to predict such effects. Accordingly, nonlocality, which is entailed neither by (a) nor (b), need not follow, unless of course it is independently derived from the formalism itself, which, as I said, does not appear to be the case thus far.[30]

Plotnitsky clearly states that the nonlocality of the quantum mechanics should not be absolutized so as to be seen as a total critique of quantum mechanics. Following Bohr, he stresses that the quantum mechanics can allow for such states but it does not mean that it cannot measure the effects of such nonlocalizable efficacies. Insofar as the radical alterity of the efficacies are concerned – this is also what constitutes the radical break from the classical – it is not a matter of measurement but of the radically unknowable.

In a similar fashion, in Newtonian physics, the force of gravity could not be verified as an empirical truth but it was always possible to show in mathematical formalism (i.e., the constant of gravity) the way it worked on actual objects, and, hence, the *actio in distans* was always a problem, though it was manageable through such formalism. However, when the EPR approached the quantum mechanics the problematic presence of *actio in distans* was somehow forgotten: they insisted on the following: if one should not allow any *actio in distans*, one should be able to define both the efficacies and how they produce the observable effects in mathematical formalism. Yet, the way Bohr replied to the EPR, under the light of the "radical discontinuity," and complete-incomplete complementarity, put forward a way of thinking where locality could not preserve itself as a problem because even the question of being local or nonlocal becomes unlocalizable, or undecidable, and hence, should be considered in a general economy, or, in a complementarity where the local-nonlocal and the complete-incomplete are preserved as binaries without yielding to a synthesis. In other words, as Plotnitsky offers in *Complementarity*, such an approach required a Batallian sense of a general economy instead of

a restricted one which actually determined the EPR argument.

*

So my question, with respect to musicality, is whether the musicality that Einstein ascribed to the non-foundational physics of Niels Bohr contained a musicality which came only *after the event*: that is, after the radical discontinuity that one generally tends to "jump over." Can all this be pointing to an approach to *actio in distans* as the unlocalizable location of "location" itself?

The unlocalizable location of location that one wants to locate if one cannot bear standing in the *midst of one's noise*?[31].

[1] Einstein, A., "Autobiographical Notes" in., *Albert Einstein: Philosopher-Scientist*, ed. Schilpp, P.A. Illinois: Northwestern University and Southern Illinois University, 1970, pp. 45-47.

[2] Bohr, quoting from his favourite novel, *The Adventures of a Danish Student* by Paul Martin Möller in "Unity of Human Knowledge," *Essays 1958-1962 on Atomic Physics and Human Knowledge*. New York: John Wiley and Sons, 1958, p. 13.

[3] See especially, Chaps 1 and 2 in Plotnitsky, A. *The Knowable and the Unknowable*, Ann-Arbor, Michigan: University of Michigan Press, 2002

[4] As Bohr put it: "The quantum theory is characterized by the acknowledgement of a fundamental limitation in the classical physical ideas when applied to atomic phenomena. The situation thus created is of a peculiar nature, since our interpretation of the experimental material rests essentially upon the classical concepts. Notwithstanding the difficulties which, hence, are involved in the formulation of the quantum theory, it seems, as we shall see, that its essence may be expressed in the so-called quantum postulate, which attributes to any atomic process an essential discontinuity, or rather individuality, completely foreign to the classical theories and symbolized by Planck's quantum of action." Bohr, N., *Atomic Theory and the Description of Nature.* New York: AMS Press, p.53.

[5] "What Life Means to Einstein: An Interview by George Sylvester Viereck," for the October 26, 1929 issue of The Saturday Evening Post.

[6] *The Knowable and the Unknowable*, p. 106.

[7] *K&U,* p. 30.

[8] *K&U,* p. 31.

[9] *K&U,* p. 32.

[10] As Bohr observed: "Certainly the issue is of a very subtle character and suited to emphasize how far, in quantum theory, we are beyond the reach of pictorial visualization." "Discussion with Einstein," .*Albert Einstein: Philosopher-Scientist*, p. 232.

[11] "For example, it may not be, and in Bohr's interpretation is not, possible to assign the standard

attributes of the objects and motions of classical physics to the ultimate objects of quantum physics. It may no longer be possible to speak of objects or motions (such as particles, or waves, for example), which, however, does not imply that nothing exists or everything stands still." *K&U*, p.3.

[12] *K&U*, p. 3.

[13] For "double-slit experiment" which is the arch-experiment for wave-particle undecidability, see, Plotnitsky, A. *Complementarity*, Durham: The Duke University Press, pp 95-104; "'In Principle Observable': Werner Heisenberg's Discovery of Quantum Mechanics and Romantic Imagination," *Parallax* 32, Vol 10, Number 2. London: Routledge: 2004; K&U, pp. 58-74.

[14] After discussing Einstein's, and his followers' approach to quantum phenomena – that is, by a concentration on the particlelike character which still makes use of the classical concepts, such as momentum, position, and time-space correlation (rendered irrelevant by Planck's discovery) – Bohr draws the following conclusions about the question of visibility and causality:

The fundamental indeterminacy which we meet here may … be considered as a direct expression of the absolute limitation of the applicability of visualisable conceptions in the description of the atomic phenomena, a limitation that appears in the apparent dilemma which presents itself in the question of the nature of light and of matter. The resignation as regards visualisation and causality, to which we are thus forced in our description of atomic phenomena, might well be regarded as a frustration of the hopes which formed the starting-point of the atomic conceptions. Nevertheless, from the present standpoint of the atomic theory, we must consider this very renunciation as an essential advance in our understanding. (*Atomic Theory and the Description of Nature*. pp. 114-15.)

Without doubt, Einstein-Bohr debate can be most closely observed in what is known as EPR (Einstein-Podolsky-Rosen) argument, and Bohr's reply to that. For a detailed account of this argument, see *Complementarity*, pp 149-90.

[15] *K&U*, p. 42.

[16] *K&U*, p. 52.

[17] *K&U*. p. 54.

[18] The following is a paraphrase of *Complementarity*, pp. 121-148.

[19] However, Plotnitsky also carefully points to the fact that despite this radical discontinuity, quantum physics still works on a certain type of "idealisation," and a "model":

Quantum mechanics in Bohr's interpretation is neither causal nor deterministic nor realist in any of the senses described earlier, most specifically in the sense of the possibility of assigning any specific form (particlelike or wavelike, or other) of independent physical reality to quantum objects or processes. The latter may, at most, be said to be real or, again, may relate to something that exists (even when we are not there to observe it), but this existence or this

“reality” appears to prevent us from conceiving of the way in which it exists. This is how we are compelled to idealize these objects and processes in nonclassical model of quantum mechanics as complementarity. Ultimately, such concepts as “objects” and “processes” may not be applicable either, however we define them, even at the level of idealization or model, and indeed, in the case of complementarity, specifically at this level. In other words, complementarity idealizes quantum “objects” and “processes” as something to which no possible physical description or conception is applicable. (*K&U*, p.56)

[20] Quoted in *Complementarity*, p. 124.

[21] *Complementarity*, pp. 149-50.

[22] Philosophically speaking, this famous EPR argument, when thought in a complete-incomplete complementarity, can be understood, as different approaches to the unthought: one which is determined to map out a thought on the unthought, as something thinkable; the other, interested in developing an approach to the unthought, while at the same time, preserving the unthought as the unthought (i.e., its radical alterity).

[23] *Complementarity*, p.133.

[24] *Complementarity*, .134 -35.

[25] Plotnitsky carefully distinguishes between “Hegelianism” and Hegel. See especially his *In the Shadow of Hegel: Complementarity, History and the Unconscious*, University Press of Florida, Florida: 1993 and the book he edited, *Idealism without Absolutes: Philosophy and Romantic Culture*, SUNY Press, New York: 2004.

[26] *Complementarity*, 143 – 44.

[27] “ As far as the incompleteness of the quantum mechanics is concerned, Bohr argues that the assumptions of the EPR argument are problematic and inapplicable under the conditions of quantum mechanics. In other words, the latter does not depend on these assumptions or that logic. It cannot, therefore, be judged incomplete by criteria based on them, insofar as the data itself is derived from quantum mechanics. The physical data of the EPR argument is not only consistent with quantum mechanics, but it cannot be obtained otherwise, and the EPR predictions are possible only on the basis of the quantum mechanical formalism. Bohr argues that both EPR’s definition of reality and their criteria of completeness are inapplicable in the case of quantum mechanics. One, cannot, therefore claim that quantum mechanics, which is not a classical theory, is an incomplete theory by criteria defining the completeness of classical theories, insofar as it fully accounts for its data and insofar as this data cannot be accounted for by classical theories.” *Complementarity*, pp. 151-52.

[28] The following detailed account of the question of “physical reality” by Plotnitsky is also useful for understanding the change in EPR’s strategy:

“Two particles with respective momentum and position variables (p 1, q1) and (p2, q2) are in a state with definite total momentum P=p1+p2 and definite relative distance q=q1- q2. This, of

course, is possible since P and q commute. The particles are allowed to interact. Observations are made on particle 1 long after the interaction has taken place. Measure p1 and one knows p2 without having disturbed particle 2. Therefore, (in their [EPR] language), p2 is an element of reality. Next, measure q1 [without simultaneously measuring p1] and one knows q2, again without having disturbed particle 2. Therefore q2 is also an element of reality, so that both p2 and q2 are elements of reality. But quantum mechanics tells us that p2 and q2 cannot simultaneously be element of reality because of the noncommutativity of the momentum and position operators of a given particle [and thus both cannot be measure simultaneously]. Therefore quantum mechanics is incomplete. (Pais, Abraham." Subtle is the Lord …": The Science and the Life of Albert Einstein Oxford: Oxford University Press: 1982, pp 455-56, quoted in Complementarity, p. 155.)

"However, such a system of measurement, required in the first place a series of assumptions, and necessarily, metaphysical assumptions. These were; 1) the system consisting of two interacting particles may be assigned a combined momentum and a difference of positions; 2) either conjugate variable – position or momentum – by itself can be measured with full precision for both particles at any point; and 3) the other conjugate variable can be calculated with full precision in the EPR situation. In view of these facts, EPR made a – meta-physical and metaphysical – assumption that both particles continue to possess both positions and momenta as intrinsic properties after the interaction and, by implication, possess them before the interaction or indeed at all points. These considerations, in the authors' view, imply that quantum mechanics is an incomplete theory, since it disallows the possibility of determining these properties simultaneously. Quantum interactions disallow the EPR assumptions, however, in view of considerations that prevent one from assigning or, again, defining any physical variables prior to the local process of measurement, defined by the interaction, itself quantum, between the object and the measuring instruments.

"The EPR argument and their very criteria of completeness and reality are, Bohr argues, based on "ascrib[ing] an element of reality to each of the quantities, represented by quantum mechanical variables"(QTM, 145), which are exactly predicted for the second particle through measurement performed in S1 (the local system associated with the first particle), but are not measured simultaneously at any point in their local system (S2). Such an ascription is, according to Bohr, impossible under the conditions of quantum mechanics, within which the EPR argument operates and on which it depends in deriving its data. In order to make it possible, one would have to measure both the position and momentum simultaneously in S2 which cannot be done." *Complementarity*, pp. 157-58.

[29] However, as Plotnitsky explains, the question of nonlocality was already implied by both the original EPR critique and also Bohr's reply to that. If Bohr's reply not only pointed to the impossibility of measuring both the momentum and position simultaneously but also to the impossibility of ascribing such variables not even to one particle in the absence of such a "physical reality," this impossibility was also designed to ward off any possible future critique by the EPR as to the nonlocality of the quantum mechanics. *K&U*, p. 92.

[30] *K&U*, pp. 92-3.

[31] “Not to be dead and yet no longer alive? (…) It seems as if the noise here has led me into fantasies. All great noise leads us to move happiness into some quiet distant. When a man stands in the midst of his own noise, in the midst of his own surf of plans and projects then he is apt also to see quiet, magical beings gliding past him and to long for their happiness and seclusion: women. He almost thinks that his better self dwells there among the women, and that in these quiet regions even the loudest surf turns into deathly quiet, and life itself into a dream about life. Yet! Yet! Noble enthusiast, even on the most beautiful sailboat there is a lot of noise, and unfortunately much small and petty noise. The magic and the most powerful effect of women is, in philosophical language, action at a distance, **actio in distans**; but this requires first of all and above all – distance”, Nietzsche, F., *The Gay Science*, Vintage Books, New York: 1974, Fragment 60, pp. 123-4.

← PREVIOUS NEXT →

META

CONTACT
FORCE-INC/MILLE PLATEAUX

IMPRESSUM
DATENSCHUTZERKLÄRUNG

TAXONOMY

CATEGORIES
TAGS
AUTHORS
ALL INPUT

SOCIAL

FACEBOOK
INSTAGRAM
TWITTER